ACTIVE SOOT FILTER REGENERATION

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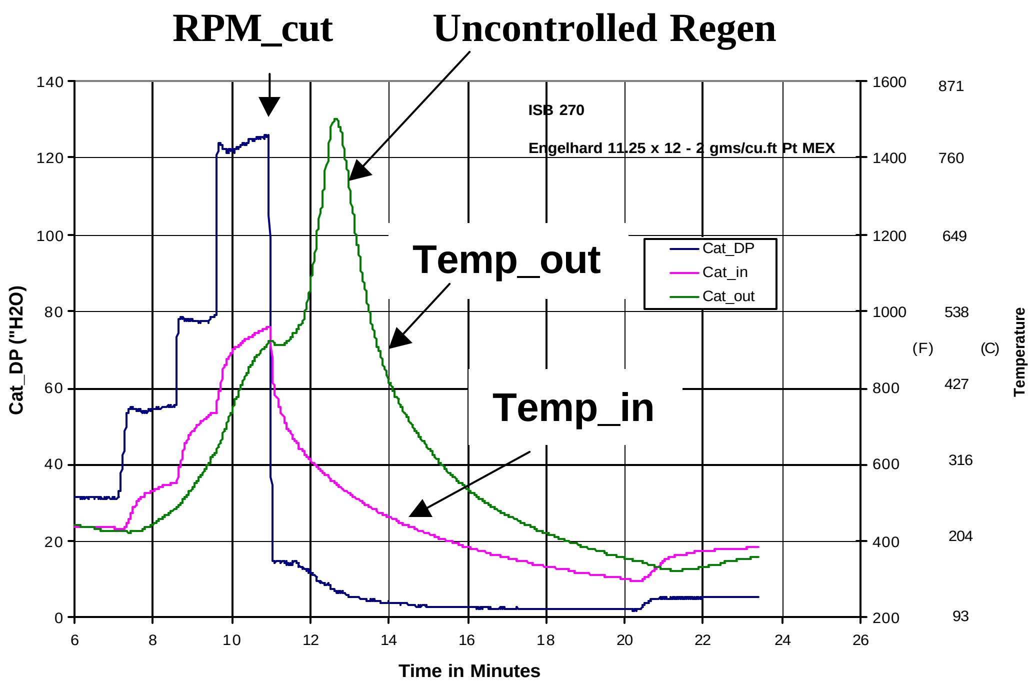
Outline of talk

- Why active regeneration
- Types of active regeneration
- Three modes of soot oxidation
- Experimental system used in investigations
- Typical experimental data
- Conclusions and future work

Need for active regeneration

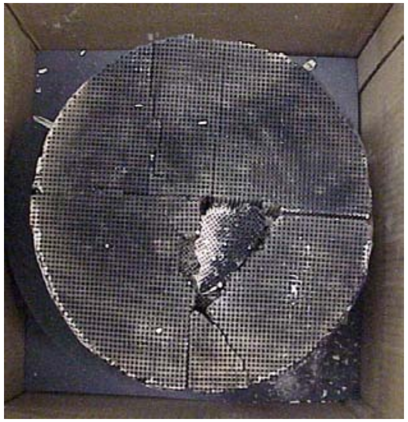
- NJT passive soot filter field test
  - 17 filters used
  - in service 7 to 67 months, 25,000 to 272,000 miles
  - 7 failed emissions, 5 cracked or melted, 7 excess backpressure
- Navy soot filter project
  - only 30% of applications data logged would work with passive soot filters
- NYC hybrid bus project
  - active regeneration assistance needed to make application robust
- In house testing
  - excess soot loading leads to soot filter failure by melting (uncontrolled regeneration)

What we are trying to prevent - Uncontrolled Regeneration



Hi Temp - Melting

Temp Gradients - Fracture



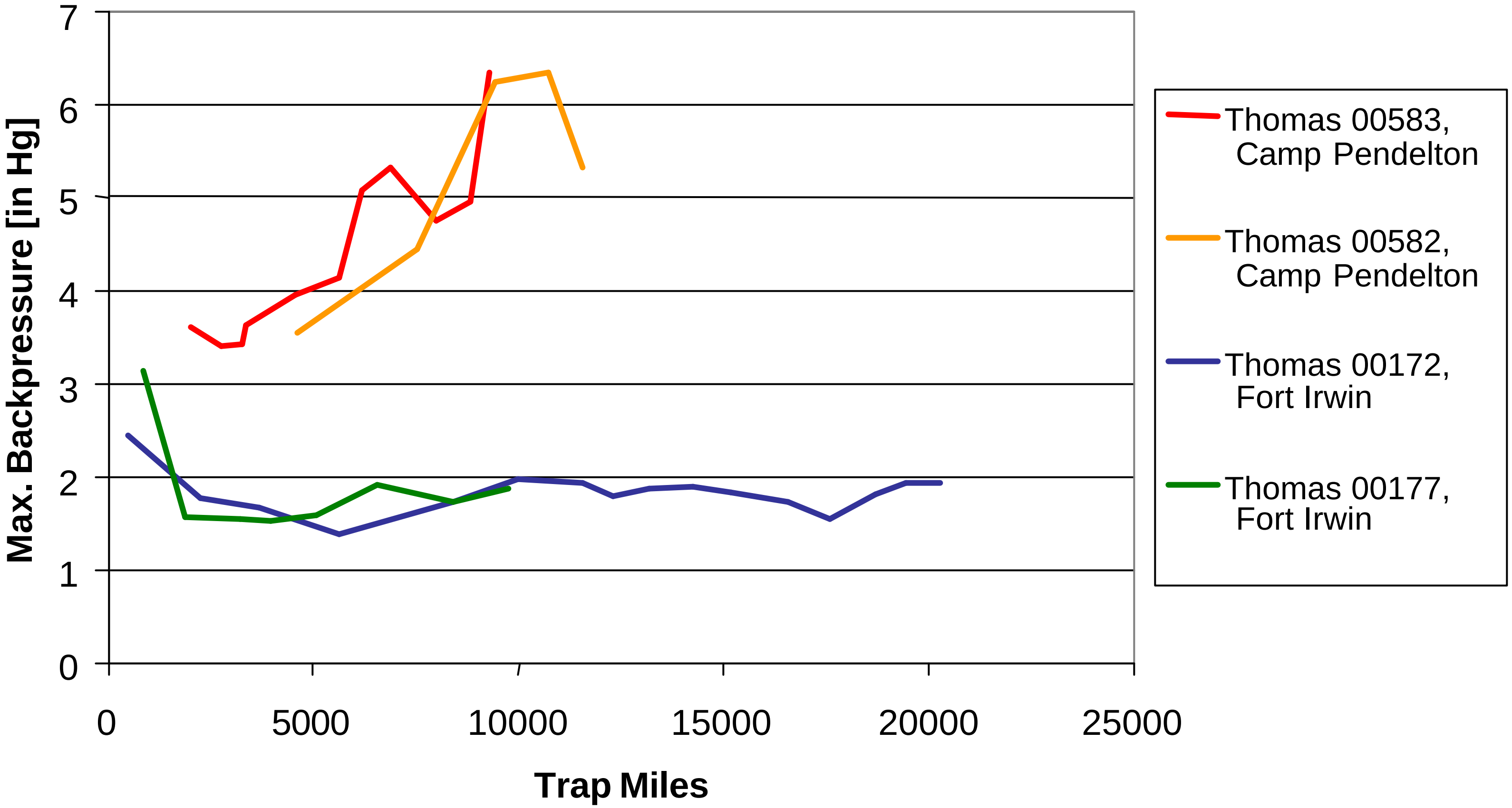
Low load operation

➡ Excessive soot loading

➡ High load operation ignites soot

➡ ***UNCONTROLLED REGENERATION***

Navy Soot Filter Project-Passive Trap Field Test

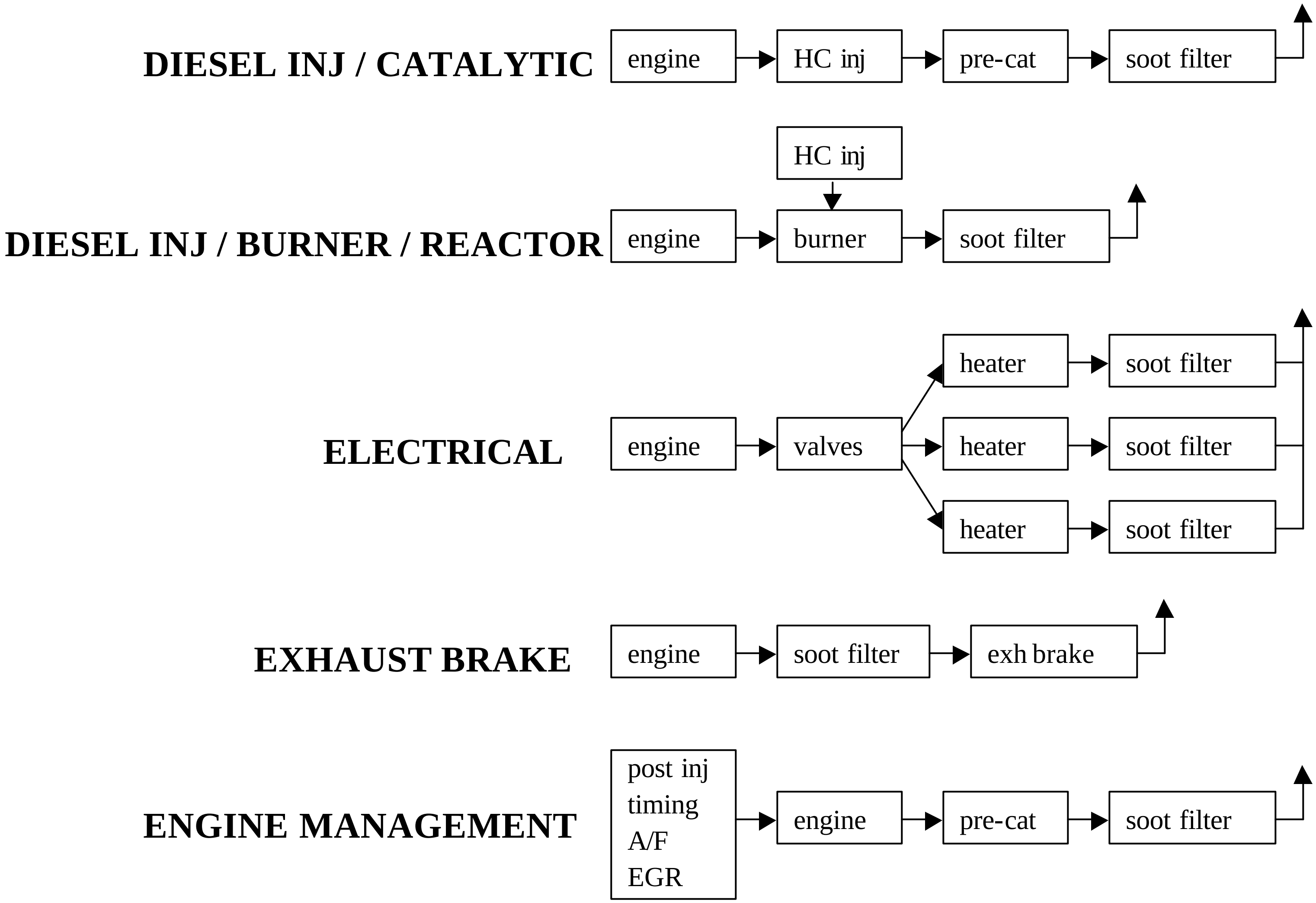


Robust particulate trap

- Able to regenerate in any application, independent of duty cycle
- Self monitoring for problems or need for service
- Easily applied to any application with a minimum of special mapping and test work

System concepts

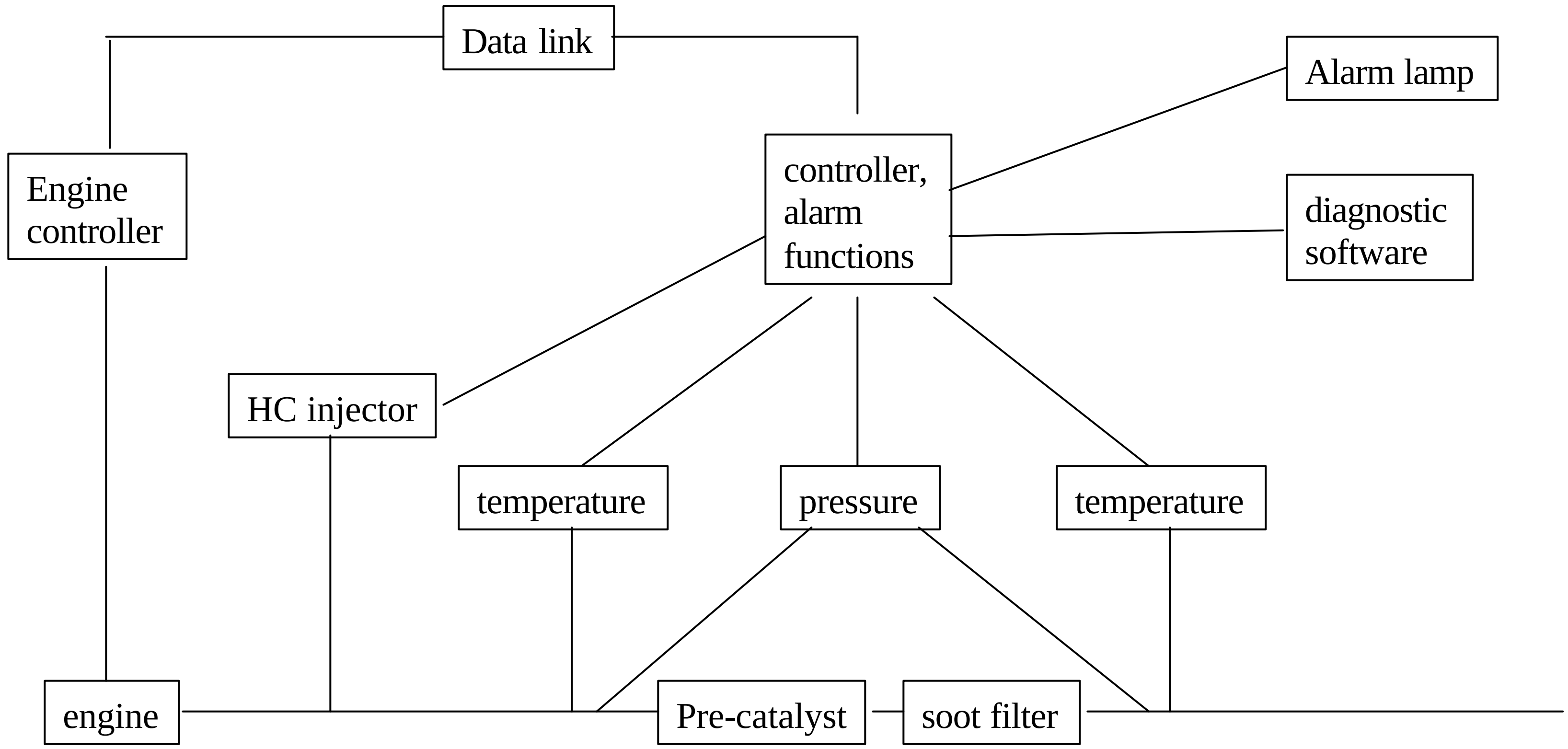
(controls and sensors not shown)



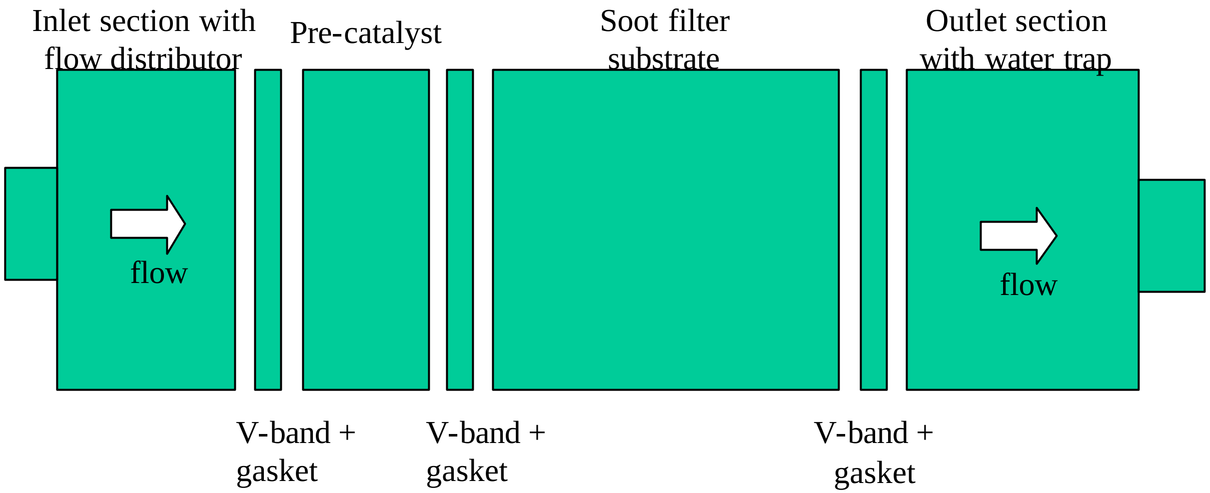
Simple view of soot filter regeneration mechanisms

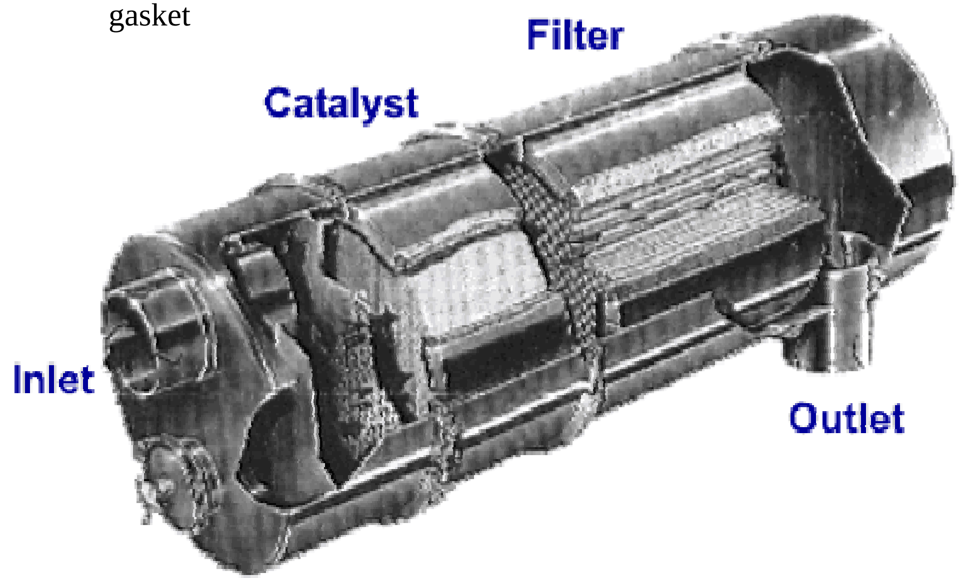
MECHANISM	GEOMETRIC REACTION CHARACTERISTICS	ACTIVE TEMPERATURE RANGE, deg.C	ACTIVATION ENERGY, KJ/MOLE	USEFUL FOR
OXIDATION BY NO2	Proportional to NO2 available and soot layer thickness	200 to 400	20 to 40	Passive or engine management
CATALYTICALLY ENHANCED OXIDATION	Proportional to catalyst surface area	>300 deg.C	Depends on catalyst	Passive, engine management, or HC injection
DIRECT OXIDATION	Proportional to total soot present	> 450 deg.C	95 to 170	HC injection

Experimental system investigated

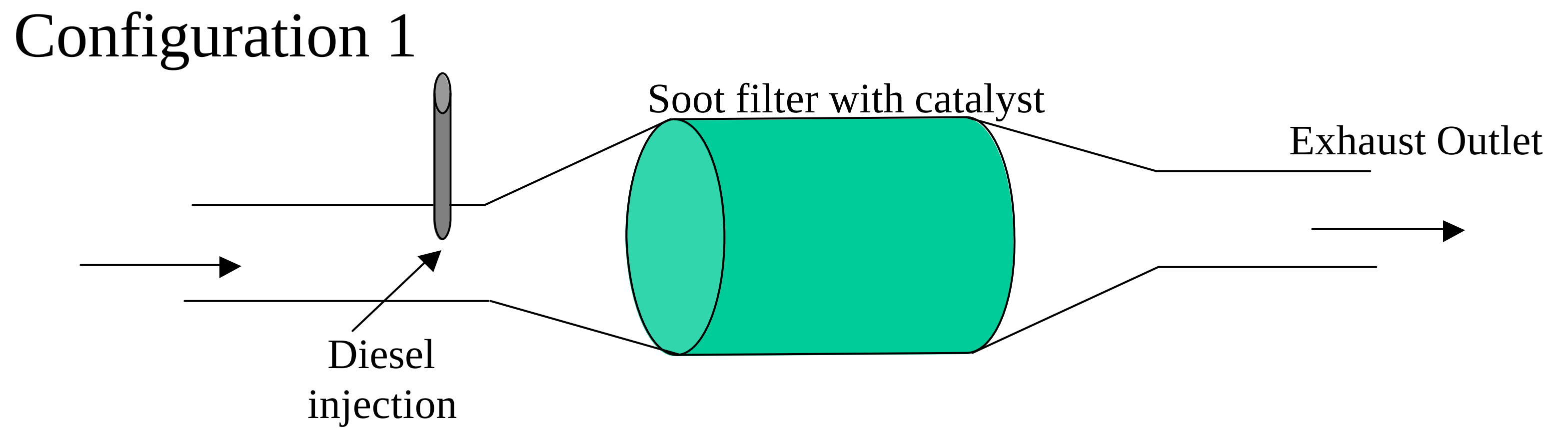


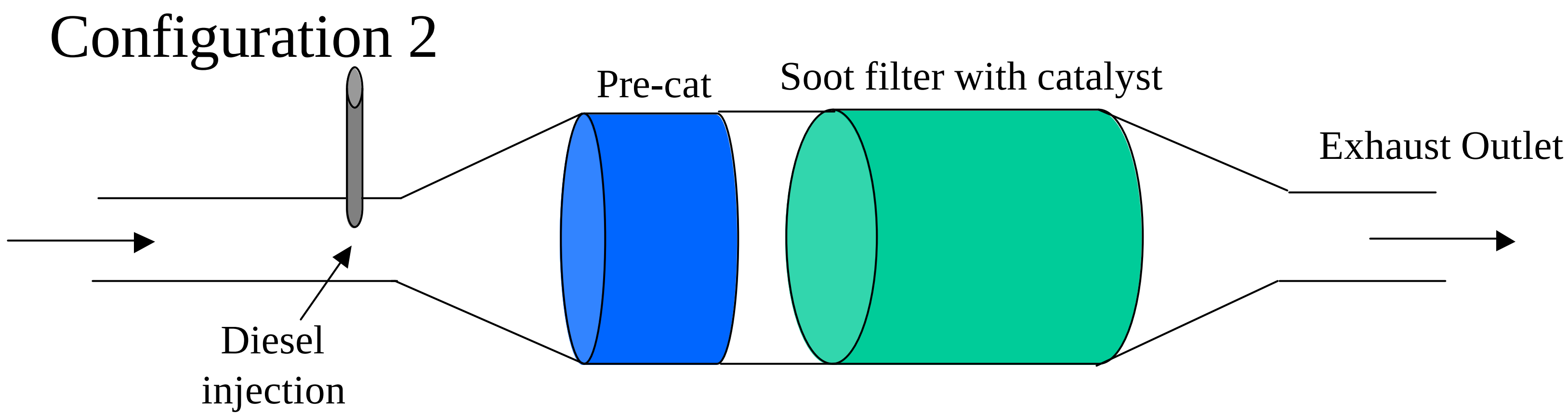
Soot Filter Assembly



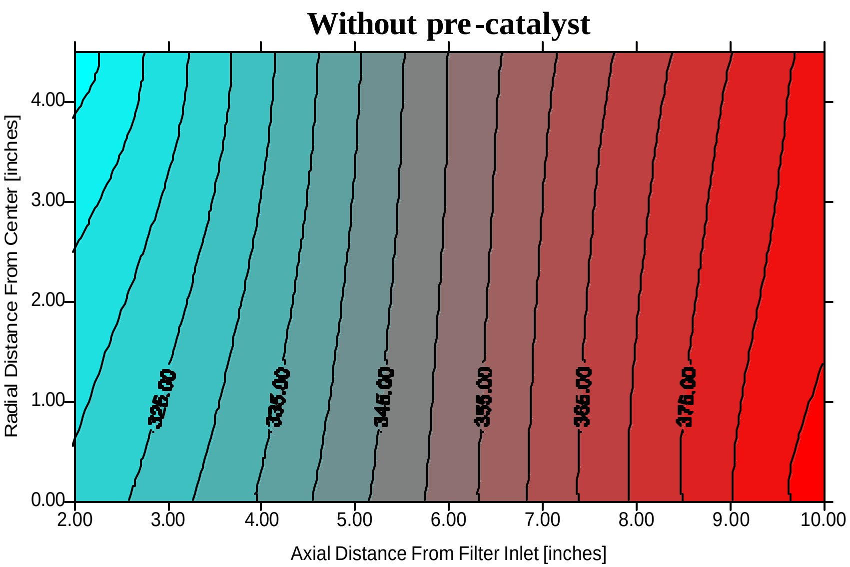


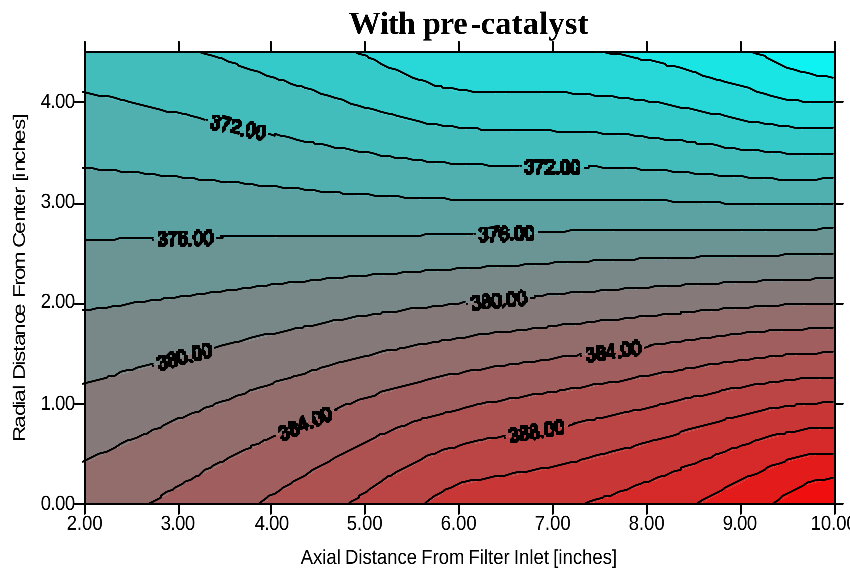
Exhaust HC Injection with Catalytic Regeneration



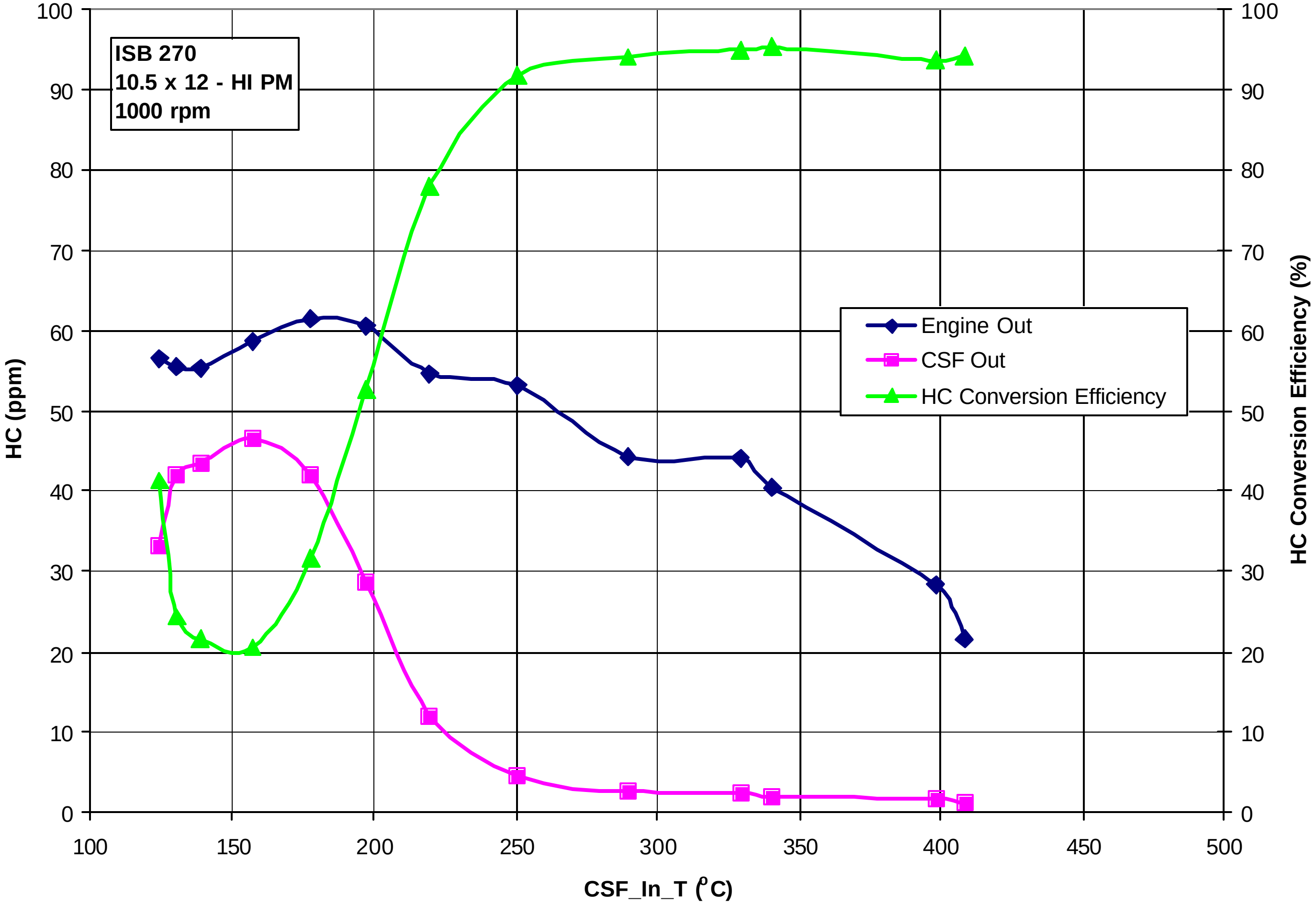


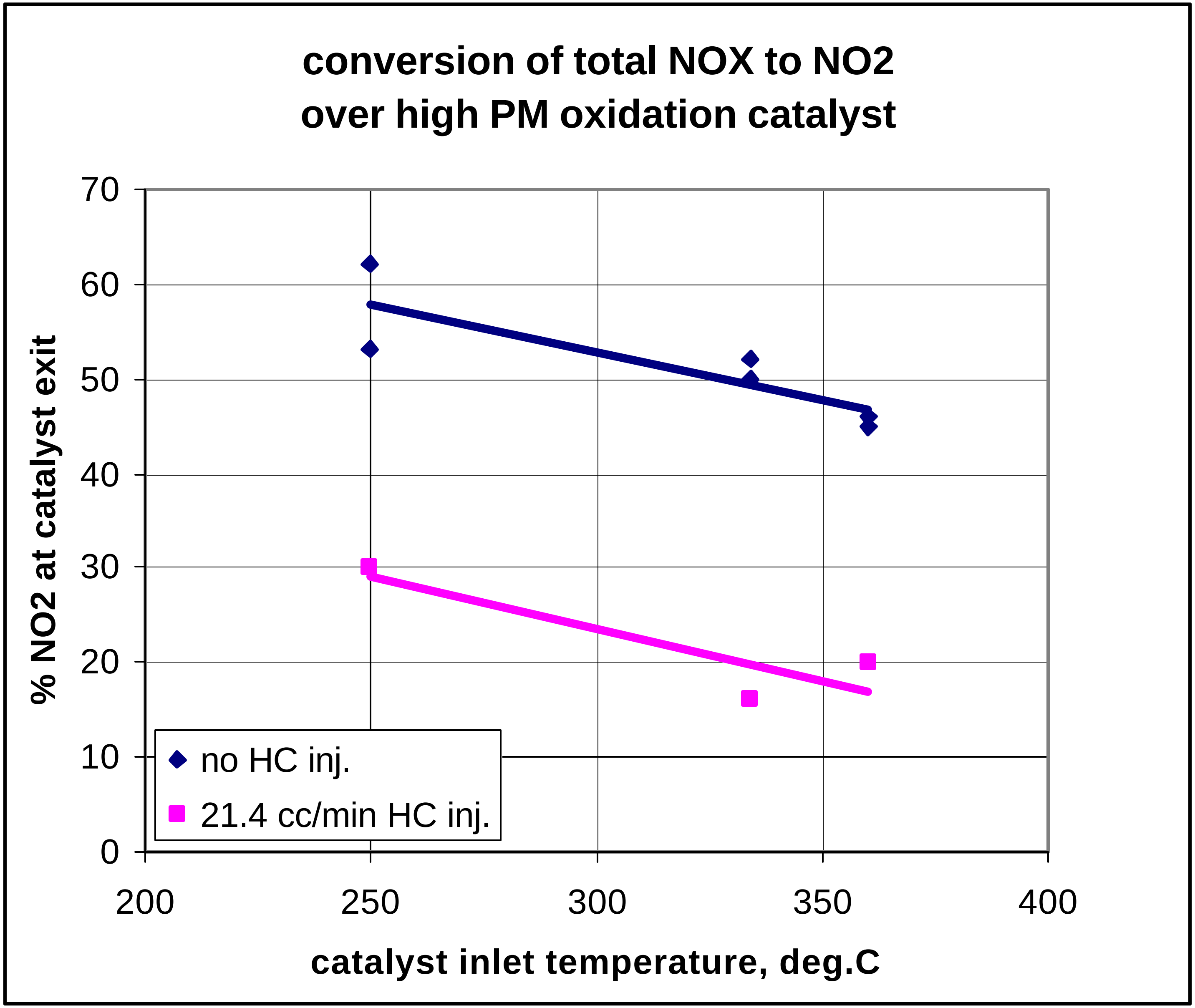
Soot filter temperature distribution during HC injection [21.4 cc/min] - without and with pre-catalyst



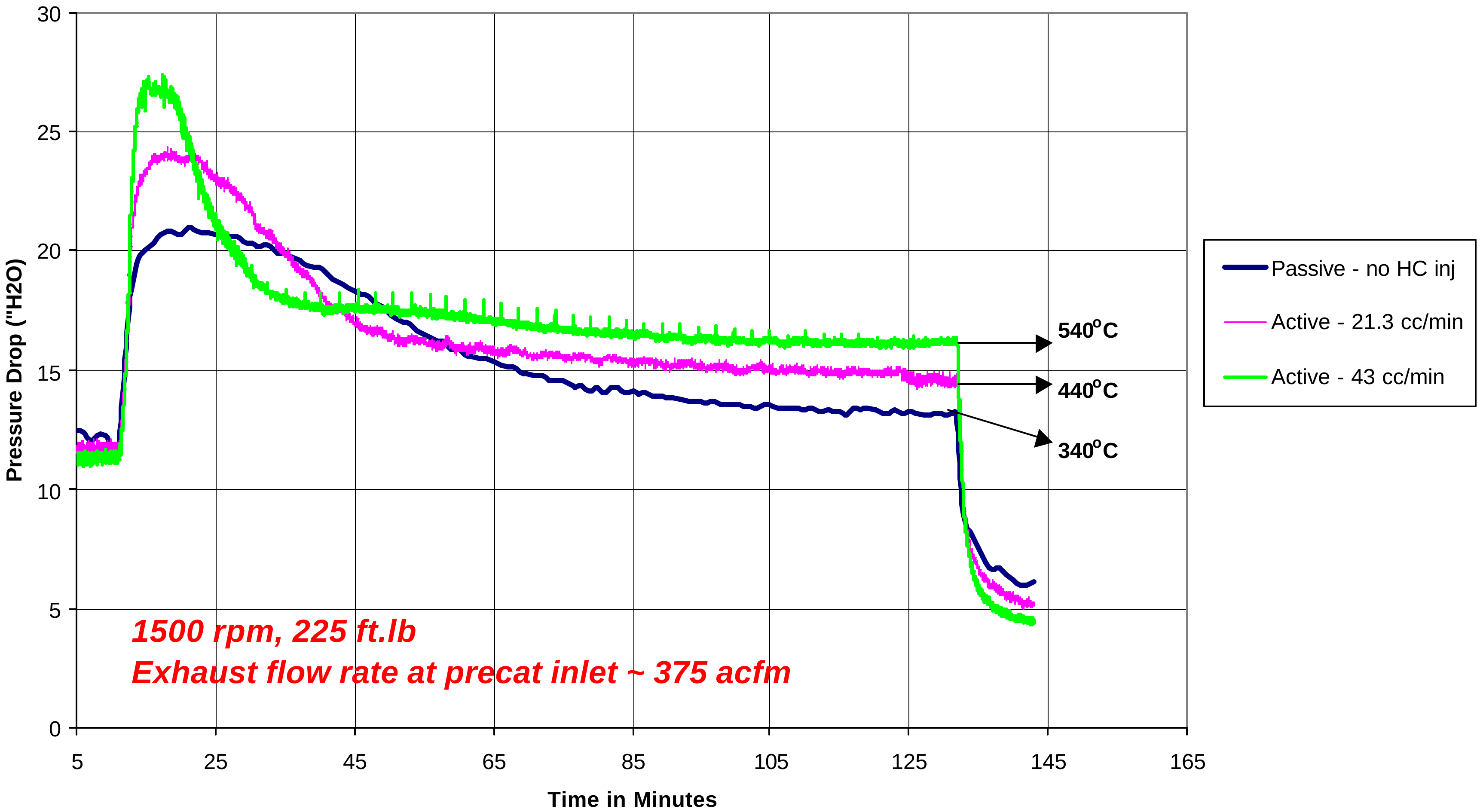


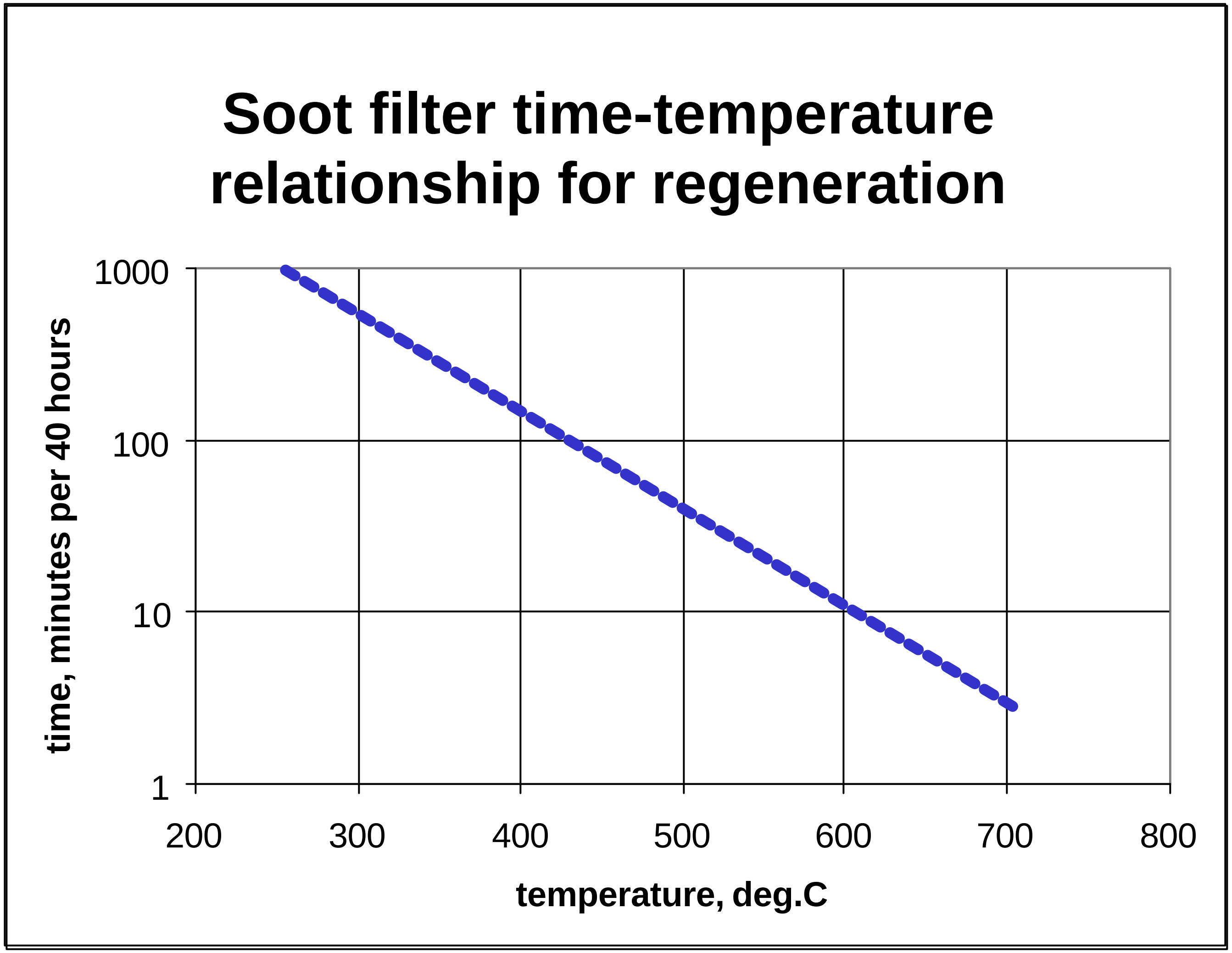
HC light-off curve




conversion of total NOX to NO2
over high PM oxidation catalyst
% NO2 at catalyst exit
70
60
50
40
30
20
10
0
200
250
300
350
400
catalyst inlet temperature, deg.C
no HC inj.
21.4 cc/min HC inj.

Soot filter regeneration using HC injection




Soot filter time-temperature relationship for regeneration
1000
100
10
1
200
300
400
500
600
700
800
time, minutes per 40 hours
temperature, deg.C

Regeneration behavior

- Active regeneration is required once every 24 to 40 hours if duty cycle is too low for passive regeneration
- Soot filter system must be at about 300 deg.C before HC injection can begin
- HC injection should be maintained for required regeneration time, and modulated to follow engine transients to maintain target temperature
- Risk of damage due to uncontrolled regeneration is managed by a combination of
  - limiting maximum soot load
  - achieving as complete regeneration as possible
  - higher exhaust mass flow rate at idle

Conclusions

- HC injection can effectively regenerate soot filters
- System performance and operating characteristics have been defined
  - need for pre-catalyst
  - lower temperature limit for HC injection
  - time - temperature relationship for regeneration

- Future work
  - further system optimization
  - integrate with engine management
  - integrate with NOX aftertreatment
  - minimize performance and fuel economy penalties
  - continue to develop other concepts